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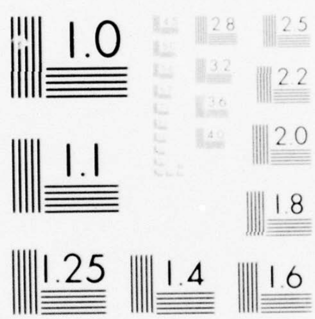

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U. S. Army Engineer Waterways Experiment Station
CORPS OF ENGINEERS
Vicksburg, Mississippi

MISCELLANEOUS PAPER T-69-1

OPERATIONS RESEARCH/SYSTEMS ANALYSIS

by

J. F. Smith

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FOREWORD

This paper was prepared for presentation at a colloquium held at the U. S. Army Engineer Waterways Experiment Station (WES). The content is a summary of information obtained as result of the author's attendance at the Operations Research/Systems Analysis Executive Course, U. S. Army Management School, Fort Belvoir, Virginia, in September 1968.

This paper was prepared by Mr. James F. Smith while working under the general direction of Mr. C. B. Patterson, Chief of the Technical Services Division, and Mr. D. L. Neumann, Chief of the Electronic Computer Branch.

The author gives full credit for all information contained herein to the U. S. Army Management School. References are marked to the several documents listed in the bibliography.

Colonel Levi A. Brown was Director of the WES during the preparation of this paper and Mr. F. R. Brown was Assistant Technical Director.

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EXECUTIVE

ORSA

COURSE

OPERATIONS RESEARCH/SYSTEMS ANALYSIS

PART I: INTRODUCTION

1. A course in operations research/systems analysis is offered by the U. S. Army Management School, Fort Belvoir, Virginia. This school was established in 1954 as a Command Management School and restructured in 1958 to its present form. This course, first offered in January 1968, runs four weeks and utilizes nine instructors, military as well as civilian. The identifying logo is on the fly sheet and the makeup of the second class of Fiscal Year 1969 in fig. 1.

MILITARY		CIVILIAN	
Colonels	5	GS-15	5
LT Colonels	17	GS-14	4
Majors	11	GS-13	11
Captains	2	GS-12	2
2nd Lieutenant	1		
Total	36		22

Fig. 1. OR/SAEC Class No. 2-69

Purpose

2. The purpose of this course, as stated in the Army Management School Outline,[1] is to give an understanding and appreciation of the techniques used in operations research/systems analysis studies; the capability of critically evaluating the studies; the capability of interpreting

the studies to the decision maker; and the capability of managing the studies. After this four-week course, anyone working in operations research/systems analysis should be able to do the following:

a. Examine the validity of the statement of the problem.

b. Examine the validity of the assumptions.

c. Assess the validity of the input data.

d. Follow the detailed methodology and analysis.

e. Judge the validity of the criteria used.

f. Judge the logic of the conclusions and recommendations.

Guest Speakers

3. In addition to the material presented in the course, one of the main features of the course is the guest speakers. These speakers are drawn from the Department of the Army, the Office of the Secretary of Defense, and supporting civilian organizations. Such controversial topics as the M16 rifle and Main Battle Tank were discussed, as well as motivation, life-cycle model, and systems analysis in the Office of the Secretary of Defense.

PART II: DEFINITIONS

4. An old Chinese proverb states, "Wisdom begins when people start calling things by their right name." Operations research/systems analysis has gone under the names: operations analysis; operations research; systems engineering; management science; cost-effectiveness analysis; or systems analysis. Consider the following definitions.

Systems Analysis

5. Systems analysis deals with problems in which the difficulty lies in what should be done--not simply how to do it.

Operations Research Analysis

6. Operations research analysis is the use of the techniques of mathematics,[2] or logical analysis, to help a client improve his efficiency in a situation in which everyone has a fairly good idea of what "more efficient" means.

Cost-Effectiveness Analysis

7. Cost-effectiveness analysis[3] is based on the economic concept that all military decisions involve the allocation for "best use" limited resources among competing requirements.

8. Figure 2 shows the relationship between these three definitions. These analyses are usually concerned with the problems of the future, not today's problems. Operations research deals with problems that usually can be put in the form of one dependent variable with the resources formulated

mathematically. Trade-offs can be investigated. In systems analysis the objectives are usually multiple and conflicting. Trade-offs between objectives as well as resources may be investigated. It may be impossible to write a mathematical expression between objectives and resources. Judgment and intuition are used in the trade-offs.

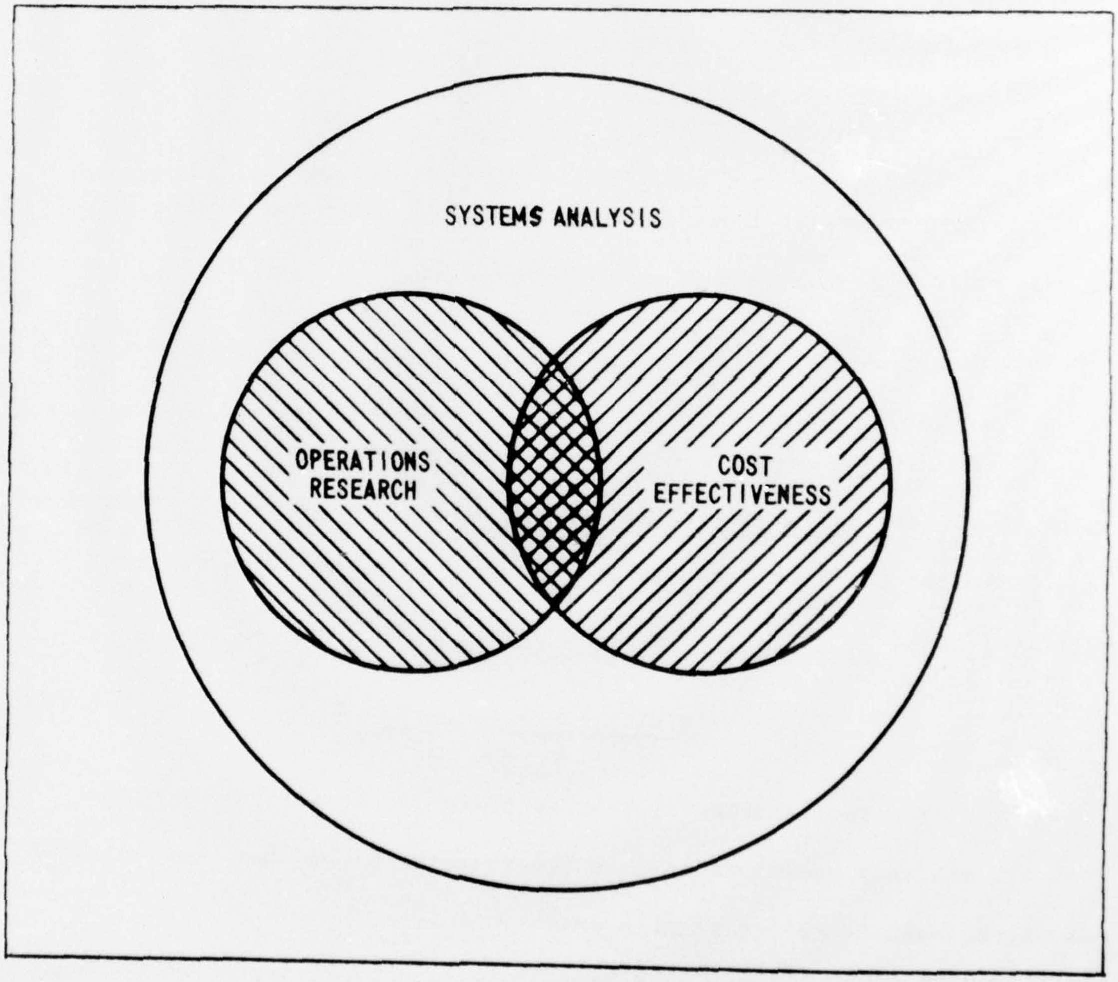

Fig. 2. Definitions' relationship

9. Is operations research a science? By definition, science is concerned primarily with the pursuit of truth and a better understanding of the world in which we live. Operations research, almost without exception, is concerned with policy; that is, the more effective manipulation of the real world, even if this may have to be accomplished without full understanding of the underlying phenomena. Its purpose is seldom merely to understand or to predict.

PART III: HISTORY

10. A brief history of operations research[4] takes us back to the Third Century B. C., when Hieron, King of Syracuse, asked Archimedes to devise a means for breaking the Roman Naval siege of his city. Since that time, political and military leaders have consulted scientists for solutions to problems of war.

Operations Research

11. By World War I, there were clear examples of early operations research on both sides of the Atlantic in the attempts to analyze military operations mathematically. In 1914 and 1915 F. W. Lanchester developed a set of equations that described the relationships between victory, numerical superiority, and superiority of firepower. Thomas Edison developed the best methods of evading and destroying submarines for the Navy Consulting Board. He did an analysis of zigzagging as a method of protecting merchant shipping. Neither of these methods affected the outcome of World War I.

12. In 1939 a nucleus of a British operational research organization already existed. One of the problems studied just prior to the beginning of the war was the integrating of the newly developing radar system of early warning against enemy air attack, with the older system of operational control based principally on the Observer Corps. This organization analyzed the variation in performance among the growing numbers of early warning stations for recommending improvement and identifying weakness.

13. Professor P. M. S. Blackett of the University of Manchester assembled three physiologists, two mathematical physicists, one astrophysicist, one Army officer, one surveyor, one general physicist, and two mathematicians in a team for operations research work. "Blackett's Circus" showed the mixed team approach to operational problems. They were allowed to cross organization lines freely with none of the restrictions usually encountered. A problem studied by this team was coordination of slant range and bearing from radar with elevation from a different device for anti-aircraft gun sites. They also did a comprehensive collection and analysis of damage statistics. Professor S. Zuckerman, proceeding from experiments with animals to systematic observations of human injuries incurred during air raids, arrived at relationships between the number of bomb casualties and the bomb load dropped on a given area. These injuries were less severe than originally thought. The ratios that he developed were validated in connection with a 500-plane raid on Coventry.

14. Aircraft attacks against U-boats were made when most submarines were either on the surface or just submerged. The planes moved in immediately to attack, and the just submerged submarine was a more favorable target than the deeper one. Depth charges, set for 100 feet with a lethal range of 20 feet, were made ineffective by the deep water setting when dropped on these submarines. Recommendations were made for a charge to be set to explode at 20-25 feet. The only fuse available had a minimum depth of 35 feet. Even with that depth setting, the increased hits were estimated from 400-700 percent. The Germans said that a new and more powerful weapon was being used against them.

15. Another important problem was what size of convoy was most effective in terms of both minimum losses and minimum escort requirements. In 1942 the average convoy was 40 ships protected by six escorts. Studies showed that increased escorts would reduce losses, but neither planes nor escort ships were available. Loss records for 1941, 1942, and part of 1943 showed that convoys with less than 45 ships suffered 2.6 percent average loss, whereas those with more than 45 ships had 1.7 percent average loss with escort vessels roughly the same, and the size of the U-boat packs fairly uniform.

16. The Navy and Air Force began work in operations research in early 1942. Problems of radar and anti-submarine warfare were the chief items of interest.

17. One Navy group's work culminated eventually in the aerial mining of Japanese controlled waters from Singapore to the home islands. Some measure of the importance of this campaign is provided in Prince Konoye's estimate that 5.7 percent of 21st Bomber Command's effort in this task had an effect on Japan comparable to the high explosive and incendiary bombing of the remainder of the command's effort. In January 1945 plans were complete, but lack of mines delayed the program until March 1945. Then 12,000 mines were laid and 1,200,000 tons of shipping sunk with less than one percent loss of the B-29's used during the operations.

18. One of the most important contributions was improvement of techniques for searching out enemy surface ships and submarines. Various search methods were devised for patrol and reconnaissance aircraft.

19. A study made of kamikaze attacks on ships recommended that large ships should maneuver violently and small ships should change course more slowly. This maneuver reduced hits from 47 to 29 percent. The study also indicated how the ships should turn to receive inevitable hits.

20. A post-war problem was a seaport--a queuing problem of how to keep ship turnaround time minimum and yet get maximum utilization of the port facility.

21. In 1946 the Air Force sponsored, for ten million dollars, Project RAND (Research and Development Corporation). In 1949 the Army budgeted one million dollars for Army operations research. Today Army funds Research Analysis Corporation, which is comparable to the RAND Corporation, and at least 80 percent of their budget is used studying military operations research; however, today military operations research is no longer concerned merely with problems of achieving optimum results. It must develop predictions of the results that may be expected from adopting proposed courses of action. These predictions can then be used as guides to the development of future strategies, tactics, and weapons.

22. Non-military operations research has old management consulting firms that had already done time and motion studies in 1920 and analysis of markets prior to World War II. Techniques for quality control and industrial engineering and management consulting services were available to management in the inter-war years. Such firms offering these services were Booze, Allen, & Hamilton and Arthur D. Little, Incorporated.

23. Operations research added human factors in military operations. RAND Corporation has psychologists, sociologists, economists, political scientists, and anthropologists on their staff. It also added mathematical prowess.

24. In 1949 M.I.T. established a course in the non-military applications of operations research. In November of 1952 the first number of the quarterly Journal of the Operations Research Society of America was published. Operations research is now in an intermediate stage, with usefulness demonstrated and new methods still developing. The marking of all problem areas to which operations research is applicable belongs to the future--not to its history.

PART IV: SYSTEMS ANALYSIS

25. Looking at overall systems analysis, consider the elements that make up the systems analysis approach (see fig. 3). The objective, or objectives, is the real functional need underlying the requirements for certain organizations and hardware systems. The objectives cannot be unduly restricted by confusion with performance characteristics.

1. OBJECTIVE(S)
2. ALTERNATIVES
3. COST
4. MODEL
5. CRITERION

Fig. 3. Elements that make up systems analysis approach

26. Alternatives are means by which it is hoped the objectives can be attained. Different alternatives are not necessarily equivalent. For instance, in civil defense protection of the population against a nuclear war, there are the alternatives of building shelters, building an anti-missile system, or building a deterrent system that will discourage the enemy from ever attacking. All three of these are designed to do the same job--protect the civilian population--and yet they all do it in an entirely different manner. The alternatives should not be too restrictive, as they also should not be too general.

27. The cost of each alternative is determined by considering incremental costs; these are the net costs of adopting the alternative. For an increment of cost, determine how much this buys in terms of effectiveness for each of the alternatives.

28. The model is simply relationships expressed in some ways to simulate real or expected conditions in order to foresee the expected outcome of a course of action.

29. A model assists in simplifying the problem; it helps to identify the significant components; it identifies the inter-relationships and determines which variables are important for the decision at issue.

30. The criterion is a rule or standard with which to rank the alternatives in order of their desirability and to help choose the most promising alternative.

31. Systems analysis does not make decisions. Decisions must be made by responsible officials on the basis of fact and judgment. Systems analysis is an effort to define the issues and alternatives clearly and to provide responsible officials with a full, accurate, and meaningful summary of as many as possible of the relevant facts so that they can exercise well-informed judgment. It is not a substitute for judgment.

32. All assumptions in an analysis must be explicit. A mark of a good systems analyst is that he states the basis in which he operates. Although he will not necessarily make better assumptions, his errors will be more evident.

33. Systems analysis, particularly of the type required for military decisions, is still largely a form of art. An art can be taught in part,

but not by means of fixed rules which need only to be followed with exactness. Thus, things are done that are thought to be right but that are not verifiable, are not really justified, and are never checked in the output of work. Many relatively intangible factors derived from human judgment are accepted as inputs, and answers are presented to be used as a basis for other judgments.

34. Why does it work? Because it is designed to make systematic and efficient (rather than haphazard and unguided) use of judgment by specialists or experts in the field of interest.

35. Systems analysis and cost-effectiveness analysis employ economic concepts (see fig. 4). Since the military system does not produce a source of revenue, then there are only two ways to fix the cost or fix effectiveness. First of all, the cost of the system can be fixed and its effectiveness maximized. Or, the effectiveness can be fixed and the cost of the system minimized.

COST/EFFECTIVENESS ANALYSIS

FIX COST AND MAXIMIZE EFFECTIVENESS

FIX EFFECTIVENESS AND MINIMIZE COST

Fig. 4. Economic concepts

36. The National Security from the view of the economist is simply this: There is a quantity of national resources available now and in the future; a proportion of these resources will be allocated to National Security; and the efficiency with which these resources are so allocated and used will be a

result of cost-effectiveness analysis and similar concepts. The main problem in cost effectiveness is deciding "what is effectiveness." In a missile system it may be kill probability, or in a vehicle delivery system it may be ton-mile delivery. Someone has to decide a criterion of effectiveness in terms of the system's mission.

PART V: MODELS

37. One of the most important parts of systems analysis is the model. The purpose of a model is to predict real-world behavior. An element, as shown in fig. 5, is the smallest piece. A simple model, it has two inputs and one output. Whatever this smallest element is defines the aggregation and resolution of the system.

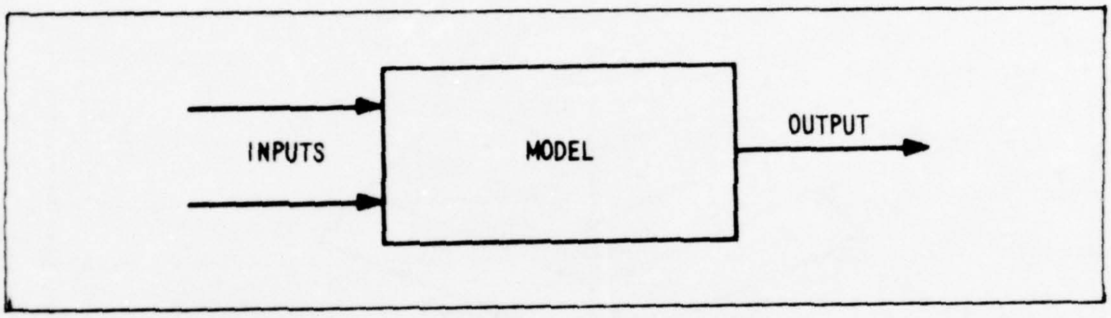

Fig. 5. Schematic of a simple model

Model Building

38. To build a model consider the following: decide which factors are relevant; select quantifiable factors; condense quantifiable relevant factors by aggregation; and establish quantifying relations between the elements.

39. Analysis of the problem area would ideally produce a completely quantified, abstract, and exact duplicate of the real-world system. But this ideal is not attainable or even necessary. Levels of abstraction imply a trade-off between limiting assumptions and exactness of fit or duplication of reality. As shown in fig. 6, the closer to the real world

the larger the model and, necessarily, more complex. However, a solution derived from any model may not necessarily be an optimum solution.

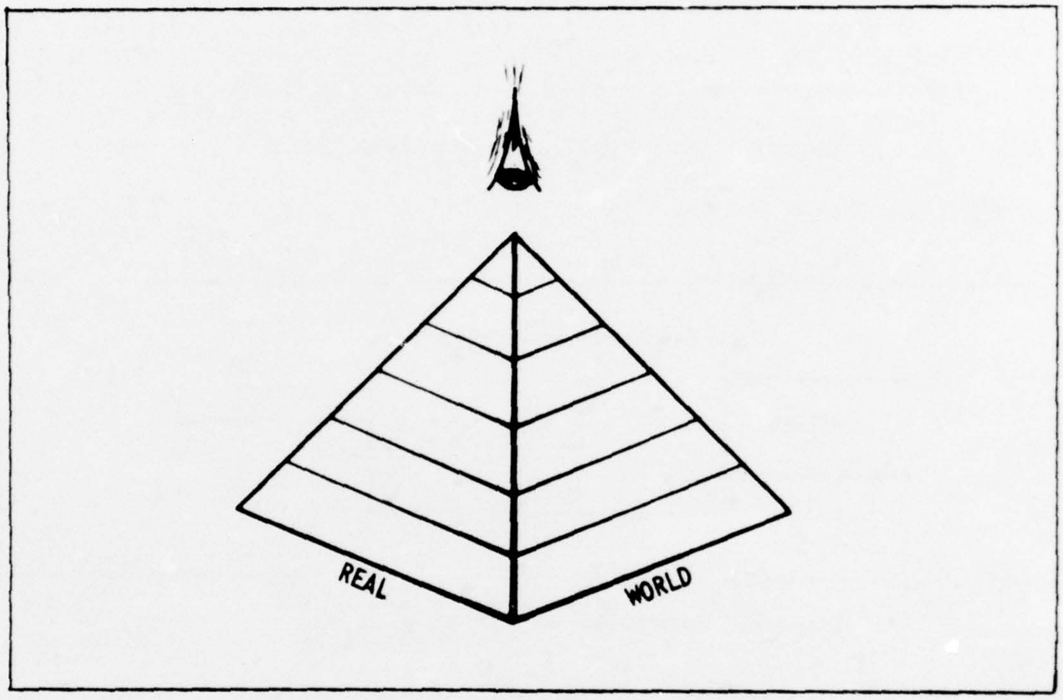

Fig. 6. Modeling levels of abstraction

Model Classification

40. In the classification of models[5] (see fig. 7), there are classifications of degrees of abstraction from the real world. The iconic or scale models are aerodynamic (such as wind tunnel), mechanical and hydrodynamic (such as the models that are used at the David Taylor Model Basin). The analog models are analog or digital computers used in the model itself, not as problem solvers, but

as a portion of the model such as using a digital computer to simulate the neuron paths in the brain. The mathematical models, by far the largest of the group, have as typical examples inventory, waiting lines, and linear programming models.

ICONIC (SCALE)
  AERODYNAMIC
  MECHANICAL
  HYDRODYNAMIC

ANALOG
  ANALOG COMPUTER
  DIGITAL COMPUTER

MATHEMATICAL
  INVENTORY
  WAITING LINE
  LINEAR PROGRAMMING

Fig. 7. Model Classification

Mathematical Models

41. The mathematical model, the most sophisticated of the model family, has the greatest predictive capability and is capable of exact *optimization techniques*. Once formulated, any of the variables of parameters included within the model may be manipulated to examine behavior of the factors represented. This also implies that once the model is built, additional information about the real world cannot be introduced without rebuilding the model. Typically, the concern is with quantitative versus

qualitative models (see fig. 8). In quantitative models, there are numbers that represent numbers in the real world. In qualitative models, numbers are put in that represent some subjective quantities in the world, such as assigning a number to driver response in a vehicle model, as opposed to assigning a number to a spring constant. Then there are probablistic versus deterministic models: in the probablistic model a degree of uncertainty exists and probability distributions are used; wherein in a deterministic model everything is exactly determined.

QUANTITATIVE	VS	QUALITATIVE
PROBABILISTIC	VS	DETERMINISTIC
READY MADE	VS	CUSTOM BUILT
DESCRIPTIVE	VS	OPTIMIZING
ANALYTIC MODE	VS	NUMERIC MODE

Fig. 8. Types of mathematical models

42. There are ready-made versus custom-built models, and just as it implies, the custom-built models are built for a particular purpose. There are descriptive versus optimizing models: the descriptive gives information about parameters within the model and will require many iterations to describe all the parameters; whereas the optimizing model gives an optimum configuration or result by the nature of the model itself. The analytical mode versus the numerical mode is simply how the model is solved, and it does not have to be solved on a computer. Analytical mode implies that it solves the problem in closed form or by some exact technique.

43. Figure 9 is titled "Techniques for Solving Models," but a better title might be "Basic Problem Forms Associated with Mathematical Models."

1. MATHEMATICAL	7. SEQUENCING
2. STATISTICAL	8. REPLACEMENT
3. INVENTORY	9. COMPETIVE
4. ALLOCATION	10. SIMULATION
5. DYNAMIC PROGRAMMING	11. SEARCH AND HEURISTIC
6. QUEUING	12. NETWORK

Fig. 9. Techniques for solving models

44. Mathematical models, or statistical models, just imply statistics are being used. The inventory models are typical of maintenance of resources in an idle state and provide some response for future demands. In allocation models the concern is with the efficient allocation of resources to meet desired objectives. Dynamic programming, a subset of mathematical programming, solves a large class of problems. Typical is the transportation problem, activity analysis problem, or production scheduling problem, where time is a consideration. Queuing is characteristic of a service facility concerned with rates of servicing, input, and output. It requires the input to look something like a discrete distribution function, such as the Poisson's distribution. The objective is to minimize both waiting time for customers and idle time for facilities.

45. A sequencing problem refers to the order in which units requiring service are serviced: whether the first in is the first out or whether the

One that requires the smallest amount of service is serviced first. A replacement problem generally has two categories. It involves items that deteriorate with use and passage of time and items that fail after a certain amount of use or time. Typical is the light bulb replacement in a large office building, and generally speaking today, the cheapest solution is to replace all bulbs at the same time after a certain period.

46. Competitive models have to do with game theory and competitive problems where the decision by one player affects decisions made by other players. In game theory there are two-person zero sum games or two-person non-zero sum games or n-person games. The three degrees of competition are (1) knowing what the competition's decision is in advance, (2) not knowing it but being able to predict it with some degree of error, or (3) knowing nothing.

47. In simulation, the special purpose languages set up problems that cannot be solved with mathematics. Problems are set up as flow rates, levels, or states plus decision points. Languages such as Simscript 1.5 and Dynamo from industrial dynamics are used to program such problems. An example is a river crossing where the purpose is to move the unit across the river with minimum time and yet allow for all contingencies. It can be handled only with some type of simulation. Simulation is a useful tool to check policy or strategy.

48. The search or heuristic model is concerned with problems of what resources to use and how to use them in order to detect the presence of some objects or conditions being sought, such as submarine detection,

hitting targets by area fire, or patrol reconnaissance. The network problems are solved with tools such as PERT and CPM (Program Evaluation Review Technique and Critical Path Method, respectively). Basically then, the solution method for mathematical model has already been decided when it is set up. One does not set up a model and then try to find out some technique that will solve it. Therefore, these categories are looked at and investigated prior to building a model.

49. One portion of model building and solution that probably has more glamour than some of the others is mathematical programming (see fig. 10), where there are two distinct areas, one deterministic and the other probabilistic. Probabilistic models use probability distributions with some stochastic, or Monte Carlo, techniques or game theory to solve the model. As in statistics techniques, random number generators are used to make many iterations where decisions are made under uncertainty.

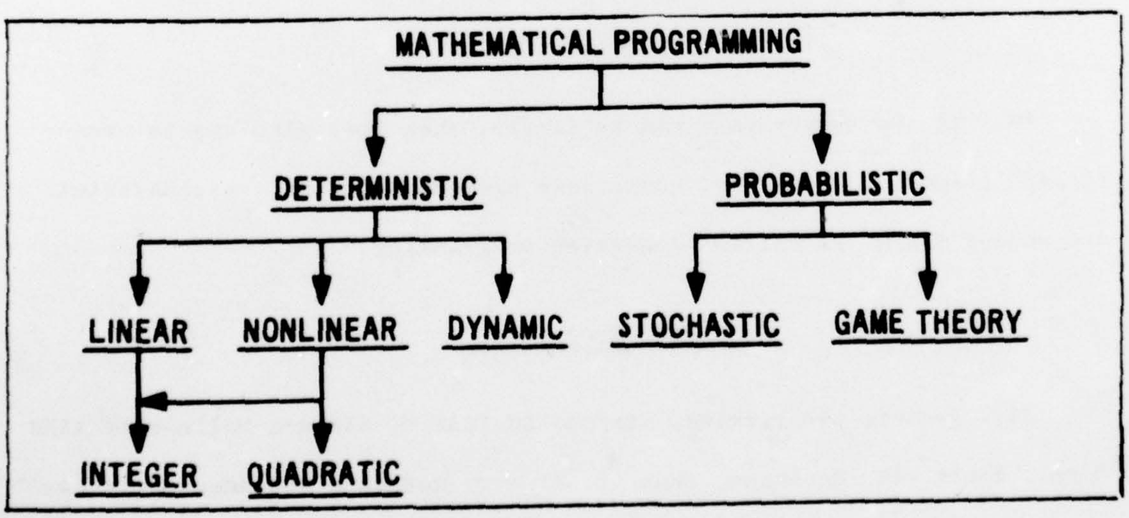

Fig. 10. Structure of mathematical programming

50. Game theory includes playing with war games where the competitor is mortal enemy. In a war game, nothing is proved by a single game, but the analysis of the game in the light of the assumptions and the stated objectives are the focal point. Probably most is gained from war games simply by setting up the structure of the game itself, such as one would set up any model.

Linear Programming

51. In deterministic models, linear programming solves for an objective function that is maximized with respect to some linear constraints. It may be solved by hand with a SIMPLEX METHOD or GRAPHIC METHOD if there are only three or four constraints. Non-negativity is assumed in the answers. Sometimes in linear programming it is desirable to have integers as a result, and a different technique called "integer programming" is necessary.

Non-Linear Programming

52. If the constraints can be linear, then they also can be non-linear; a special version of non-linear programming when the constraints are second degree is called "quadratic programming."

Dynamic Programming

53. Dynamic programming, started in 1952 by Richard Bellman of RAND Corp., deals with decisions that are time or sequence dependent. It can treat continuous or discrete systems, linear or non-linear, and it has built-in contingency plans. The major difficulty is stating the problem

One should view with extreme care the results of dynamic programming with equations set up by anyone except Richard Bellman.

Decision Theory

54. Another technique, having to do with game theory in a way, is decision theory. This one assumes that the competition is nature, the decision rules are tuned to a one-shot application, and nature cannot choose. Decision theory versus game theory can be categorized as follows: For a problem that is singular and well defined, apply a mathematical model. For a problem that is multiple and in conflict and the conflict is in nature, use decision theory. For a problem that is multiple and in conflict with an obnoxious adversary, use game theory.

PART VI: UNCERTAINTY

55. All models predict future events with variable results. Risk is that portion of the variability of future events which is measurable and quantitative. It can be insured against by adding to costs. Uncertainty relates to those phenomena which create variability and cannot be insured against by adding to costs. It does not mean complete ignorance or that no relevant experience exists. Rather, it means that the degree of ignorance is unspecified.

56. Examples of uncertainty are threats to our National Security, as to where and when; the capability of systems to perform as specified; and the capability of a cost analyst to translate the design of a system into a statement of resource requirements and costs. The latter may be dealt with by using cost sensitivity analysis, the process for examining how total system resource requirements or costs change as key system characteristics are varied over a relevant range.

Delphi Technique

57. The Delphi technique is used to determine some of the subjective probabilities. This is a technique that tries to improve the consensus method by subjecting experts' views to each others' criticism without actual confrontation and all its psychological shortcomings. It replaces direct debate by a carefully designed program of sequential individual interrogations, best conducted by questionnaires, interspersed with information and opinion feedback derived by computer consensus from the earlier parts of the program.

Decision Under Uncertainty

58. Uncertainty, or the approach to uncertainty, is shown in fig. 11, a conception of decision under uncertainty. The explicit data are obtained as basis for the probabilities, expert judgment for subjective probabilities, and then the decision is made under risk. Remember here again, that we do not make the choice but present the information to the decision maker.

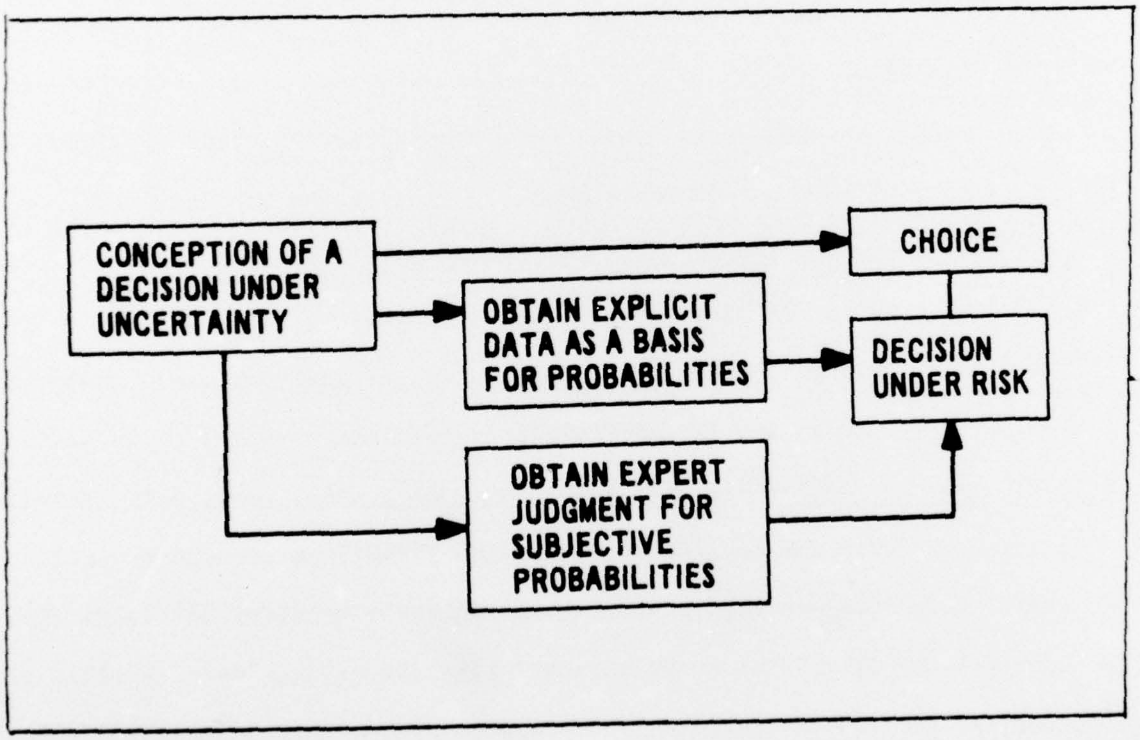

Fig. 11. Approaches to uncertainty

59. Judgment is important. It contains uncertainty; experts can be wrong. So now consider some of the pitfalls in this method called systems analysis.

PART VII: PITFALLS

60. Formulation is a leading pitfall in systems analysis (see fig. 12). It is the failure to allocate and spend a sufficient share of the total time available deciding what the problem is. The tendency to "get started" without really thinking about the problem, looking at unduly restricted ranges of alternatives, or trying to make the problem too large--all are errors in formulation. Remember that alternatives are seldom either-or but generally a range of mixes to be considered.

FORMULATION
PROCEDURAL FALLACIES
AUTHORITITIS
MECHANITIS
SEARCH
EXPLANATION
INTERPRETATION

Fig. 12. Pitfalls in systems analysis

61. Procedural fallacies arise when the customer (probably a general or admiral) is allowed to choose the criteria. This is referred to as "authorititis." "Mechanitis" is putting machines to work as a substitute for hard thinking. The only way to choose criteria is to undertake analysis. The pitfall is to believe the contrary.

62. Search pitfalls can be avoided if the evidence on which the analysis is to be based is carefully examined. Beware of "official figures"

quoted from some publication. The only thing official about them may be just the fact that they appear in the publication. Completely mistaken technical notions or facts have been included in analysis.

63. It is possible to become engrossed in the workings of a model and lose sight of the real world objectives. The model must be designed to answer real world questions, but care must be taken not to make the model the end product. There are also dangers of oversimplification in the model. The belief that there are "universal" models must be avoided. The tendency exists to ignore uncertainty or to try to remove it by assumption. All of these errors are classified as explanation pitfalls.

64. Once the analysis is complete, the results must be presented without bias to the decision maker. But this is most difficult for the systems analyst simply because of the time and work he has invested in the problem. In comparison of systems avoid putting too much faith in the values of variables which determine the strategy associated with the best system. Too often these become "official figures" without further justification. A serious problem in the interpretation is that the analyst may face severe punishment if wrong, but is seldom rewarded if right. Thus, it is imperative that the decision maker clearly define the rules under which the analyst is expected to work.

PART VIII: USE OF COMPUTERS

65. The digital computer is a tool widely used in systems analysis studies. It is not a technique of operations research. The computer as it is known today cannot help with a problem that cannot be intellectually solved without the computer.[6] The results are no better than the model which the computer has implemented. Unfortunately, the fact that a computer has been used in an analysis is frequently used to give an unwarranted aura of authenticity to the results.

66. Three major misconceptions in using computers are listed in fig. 13.[7] In using a computer there is a tendency for analysts to consider the problem analysis, program design, coding, and debugging as trivial and requiring but little time for completion. At best this attitude can result in a serious underestimation of the time required to perform these vital functions. It can also result in a poor job or miss a deadline completely. This false idea of ease of use will result in the analyst's avoiding the computer in the future.

1. OVERESTIMATING EASE OF USE
2. OVERRELIANCE ON PAST EXPERIENCE
3. OVERDEPENDENCE ON RESULTS

Fig. 13. Common misconceptions in using computers

67. Sometimes those who have experienced a degree of success in previous computer applications may rely too heavily upon the data available from these past computer runs. Programs may be extrapolated or used for a similar but entirely erroneous application with the results being worthless. This misapplication of a computer program may require extensive modification to the program before the assigned job can be correctly performed.

68. The third misconception is the assumption that results or outputs from a computer are virtually infallible. This attitude seems to grow as proficiency and enthusiasm in the use of computers increase. The computer output is a reflection of the effort expended in the development of inputs, including the expertise employed in the conception of initiating parameters, the quality of professional computer technique which went into the design and production of the program, and the relative accuracy of the various inputs. These contributions may provide a reasonable basis for supporting the final answer, but they should not preclude the intercession of sound judgment.

Conclusions

69. Systems analysis represents an approach to, or a way of looking at, complex problems of choice under uncertainty. It offers a means of discovering how to design or to make effective use over time of technologically complex structure in which the different components may have apparently conflicting objectives; that is, an approach to choosing a strategy that

yields the best balance among risks, effectiveness, and costs. Its purpose is to place each element in its proper context so that in the end the system as a whole may achieve its aim with a minimal expenditure of resources. Thus systems analysis is a common sense approach to problems of decision. "Today, systems analysts are getting to be both more modest about their claims and better at their work. If the trend continues, we may well come out with a match between claims and product." (Herman Kahn, RAND Corp., 1956.)

70. The Department of the Army is very interested in systems analysis. In the future all large procurements and requests for research and development funds will reflect this approach. The question is no longer one of whether or not to use operations reseach/systems analysis--the Department of the Army insists on it!

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